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Oregon Agricultural College Experiment Station

Hood River Branch Experiment Station

The Life-History and Control of the Rose Leaf-Hopper

An Apple Pest

By
LEROY CHILDS



CORVALLIS, OREGON

The regular bulletins of the Station are sent free to the residents of Oregon who request them.

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THE LIFE-HISTORY AND CONTROL OF THE ROSE LEAF-HOPPER

AN APPLE PEST

By

LEROY CHILDS

Entomologist and Plant Pathologist, Hood River Branch Experiment Station

Introduction

The occurrence of the rose leaf-hopper, *Empoa rosae*, in injurious numbers in several apple-growing sections of the State during 1912-13 made it advisable that a study of the life-history and control measures of this species be made. The writer was detailed in 1914 to carry on an investigation of the life-history of this species and to determine the best methods by which it could be combated. This bulletin gives the detailed results of the investigation.

The rose leaf-hopper, although of apparently wide distribution throughout the greater portion of the United States, has never been reported as becoming a pest of serious economic importance in apple orchards other than in the Pacific Northwest. Since the extreme prevalence of the leaf-hoppers during 1912-13, no general infestation of all orchards has occurred in the Hood River Valley. During both 1914 and 1915, however, younger orchards could be found swarming with these insects during the summer and early fall and much injury was done by their presence.

Distribution and Occurrence

Empoa rosae is not considered a major insect pest of the apple. It has nevertheless caused a great deal of injury in some years in the Pacific Northwest. This species, probably of European origin, has been known and reported by many investigators in nearly every section of the country, but no special mention has ever been made relative to its activities on apple foliage except in northwestern apple-growing sections.

Dr. E. P. Felt has discussed in several of his reports the activities of this insect in New York but in no case has he found it in sufficient numbers on apple to consider it a pest. Professor C. P. Gillette (1906) reported this species feeding upon apples in Colorado, stating that it was "abundant upon apple but not in injurious numbers." W. H. Brittain has found the insects prevalent upon apple foliage in Nova Scotia. Mr. G. P. Weldon states, in correspondence, that in 1915 he found the rose leaf-hopper causing noticeable injury to apples in the Grand Junction section of Colorado and that it occurred in sufficient numbers to warrant control measures. Mr. E. J. Newcomer reports from Wenatchee, Washington, that during certain seasons *Empoa rosae* is a very common insect in that section. The writer has taken this insect from the

foliage of apple in Placer County, California, where it was found in numbers but was not causing any appreciable injury.

Species of Leaf-Hoppers Found on Apple in Oregon

In Oregon there are several "Jassids" which have been observed to feed upon the foliage of apple in the adult stage, but only two have been found to undergo their complete life-cycle on this plant. These are *Empoa rosae* and *Empoasca unicolor*. These two species are distinguishable from other apple-



Fig. 1. Characteristic injury of apple leaf caused by the rose leaf-hopper.

infesting hoppers in that the former, *E. rosae*, is by far the more common hopper present and is uniformly yellowish-white in color. *E. unicolor* is slightly larger than *rosae* and possesses a glossy light green coloration. *Empoasca unicolor* is much less widely distributed than *Empoa rosae* and has been observed to be numerous in a few isolated orchards only. Other adult leaf-hoppers* which have been taken from the foliage of apple in Hood River are *Thamnotettix montanus*, Van D., *T. flavocapitatus*, Van D., *T. geminatus*, Van D.,

*Kindly determined by E. P. VanDuzee.

T. aureolus, Van D., *Empoasca viridescens*, Walsh, and *Dicraneura cruentata*, Gill. Insects which have been included in this last group never occur in any great numbers upon the apple tree. The apple appears to be only their accidental or temporary food plant.

Host Plants of Rose Leaf-Hopper

There are several host plants of *Empoa rosae* in Oregon. These can be classified in four groups, namely; (1) Plants upon which both the over-wintering and summer deposition of eggs is made; (2) winter deposition only; (3) summer deposition only, and (4) temporary food plants of migrating adults. The chief food plants of *Empoa rosae* belong to the Rose family, of which the rose, both cultivated and wild, is undoubtedly the favorite. The rose, however, serves as a food plant for the young of but one generation.

The insects hatching from the over-wintering eggs upon reaching maturity migrate for the most part to the apple. Other plants upon which the over-wintering generations occur are several of the bush fruits including wild blackberry (*Rubus ursinus*) and cultivated blackberry, Evergreen blackberry, (*Rubus laciniatus*), raspberry, Loganberry, and strawberry. With the exception of Evergreen blackberry, these plants seldom harbor the insects in great numbers. The green canes of this variety, however, are well suited for the deposition of the over-wintering eggs, large numbers of which are deposited during the fall in blackberry thickets.

The apple differs from the group just mentioned in that it serves as a food plant for two generations of nymphs; namely, insects resulting from over-wintering eggs deposited in the twigs and branches, and the summer generation, eggs of which are deposited in the leaves. The only other plant upon which both generations have been observed to undergo development is the strawberry—a crop which ranks next to the apple in importance as a fruit grown in the Hood River valley. This, together with the fact that practically all of the host plants upon which the species feeds are grown everywhere—many entirely neglected—may account for the fact that the rose leaf-hopper has become an insect of economic importance here.

Nymphs of the summer generation have been found feeding on dogwood (*Cornus douglasii*), prune, cherry, and hawthorn (*Crataegus* sp.) indicating that eggs had been deposited during the summer in the leaf tissues of these plants. In the case of prune and cherry the finding of young hoppers is very rare. Large numbers of both nymphs and adults, however, have been taken from the dogwood.

Accidental food plants of migrating adults have been observed; they include oak (*Quercus garrayana*), alder (*Alnus rhombifolia*), and cottonwood (*Populus* spp.). Professor C. P. Gillette* reports that he has specimens taken from plum, tame cherry, currant, and grape, together with several that have already been given.

*Gillette, C. P.—American leaf-hoppers of the Subfamily Typhlocybinae, Proceedings of U. S. Nat. Museum, Vol. XX—771-772.

Adaptability of Nymph to Various Food Plants

In connection with the adaptability of the nymph to food plants other than those which have been found, ten nymphs of the first and second instars were bagged on each of the following plants: peach, plum, apricot, pear, cottonwood, grape, clover, and alfalfa. Normal development occurred in all of the plants with the exception of the last three. A second attempt was tried with these, but the insects were found dead the following day. From this experiment it would appear that there are many plants, if occasion demanded, upon which this insect can undergo development.



Fig. 2. Apple tree in the foreground showing very thin foliage due to leaf-hopper infestation.

Injury

The chief injury caused by this insect is typical of that of most sucking insects; devitalization through loss of food properties needed by the plant and more particularly the destruction of chlorophyll in the leaves. The extent to which plants suffer varies directly with the degree of infestation and in most

cases is hard to define in actual injury to the host. The insects during their twenty-nine to forty days of nymphal development are constant feeders and when present in numbers are capable of removing much food that would otherwise be utilized by the plant. One insect feeding continually on an apple leaf during this period removes or destroys from one-third to one-half of the green chlorophyll. Four or five insects have been observed to remove, with the possible exception of a narrow green margin on the edge, the entire green coloration of the leaves. An injury of this extent, in the case of a general infestation over the tree, noticeably inhibits normal functioning of the leaves. Trees so infested appear yellowish-brown during late summer and are much below normal in vigor.

The insects confine their feeding to the under surfaces of the leaves entirely. The first indication of their presence is the appearance of yellow spots on the upper surfaces of the leaves. (See Fig. 1.) As feeding continues these spots become larger and more numerous until the leaf shows a decided greenish-yellow coloration. Leaves so injured are deprived from further functioning and their presence on the tree only further devitalizes it by acting as surfaces for evaporation. In cases of a severe infestation many of the injured leaves drop prematurely during the latter part of August.

Of the several plants that are subject to attack by this species the rose is by far the favorite food plant. A single generation of this insect, attacking each year, is often so extensive that the plants are killed in two or three seasons. If not killed outright the plants become so weakened from the heavy infestations during the early summer that they are unable to produce bloom and scarcely keep alive.

In the rose and to a lesser extent in the other host plants also, serious injury is caused by the deposition of the eggs in the green woody portion of the plants. As shown in Table VII an average of over one thousand eggs to each square inch of bark surface is not uncommon. This irritation to the plant often disorganizes the tissues to such an extent that the canes are killed outright. In several instances a fungus disease has been found to enter the wounds, resulting in a cracking of the bark and the retarding of the normal growth of the plant. (See Fig. 10-c.)

The egg punctures in apple twigs have never been found in sufficient numbers to cause any appreciable injury to the normal functioning of the plant, nor has the spread of any disease been associated with these punctures.

An indirect injury that has been found incidental to serious infestations is the deposition on the apples of large amounts of excrement discharged from both the immature insects and the adults. This often gives the fruit a smutty and dirty appearance, a condition which demands extra attention and wiping at time of packing. A good drenching rain occurring before the fruit is picked removes a large amount of this excrement, as it is very soluble. In years of severe infestations it would be well, if possible, to delay picking until a rain occurs; as this would save much time otherwise necessary for wiping, and materially improve the appearance of the product.

Supposed Insect Injury to Fruit

In the fall, quite often, red spots are found on some varieties of apples, Newtown especially, in the center of which appear insect-like punctures. In order to determine whether the rose leaf-hopper feeds upon the fruit or is responsible for some of this spotting of the apples, a number of fruits containing the adult insects were bagged. The results shown in Table I clearly demonstrate that the insect is unable to subsist on the fruit alone, and that it is in no way responsible for the markings that have been observed on the apples. Preventing the caged leaf-hoppers from taking food from foliage resulted in their death within twenty-four hours.

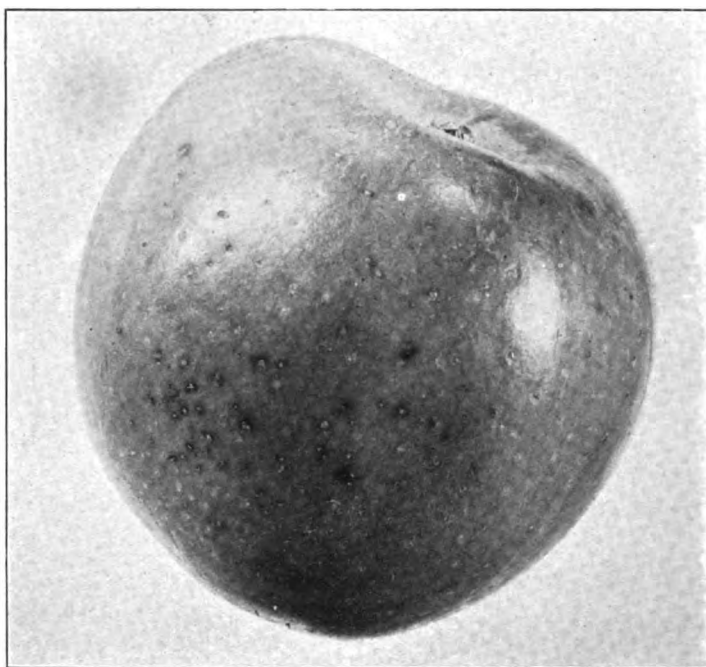


Fig. 3. An injury to apple supposed to have been caused by leaf-hoppers. Rose leaf-hoppers never attack the fruit.

TABLE I—RESULTS OF AN EXPERIMENT SHOWING THAT LEAF-HOPPERS DO NOT FEED UPON OR INJURE THE APPLE FRUIT

Bag No. Date 9-3-15	No. of In- sects Bagged	No. Apples Inclosed Without leaves	Examination of 9-4-15	Examination of 9-25-15	Variety	Injury
1	20	1	all dead		Newtown	None
2	25	1	all dead		Banana	None
3	30	3	all dead		Banana	None
4	10	1 apple and 2 leaves***	all alive	Insects still present	Newtown	None

***This fruit was watched until harvest time—at no time were insects found on the fruit or any injury observed.

As a control for this experiment two leaves were left with the apple in bag No. 4. (Table I) The insects were all found to be very much alive in this cage on the day following. The contents of bag No. 4 were watched for several weeks following the death of the insects in the other bags. Many lived until the leaves dropped. No injury was found on the fruit.

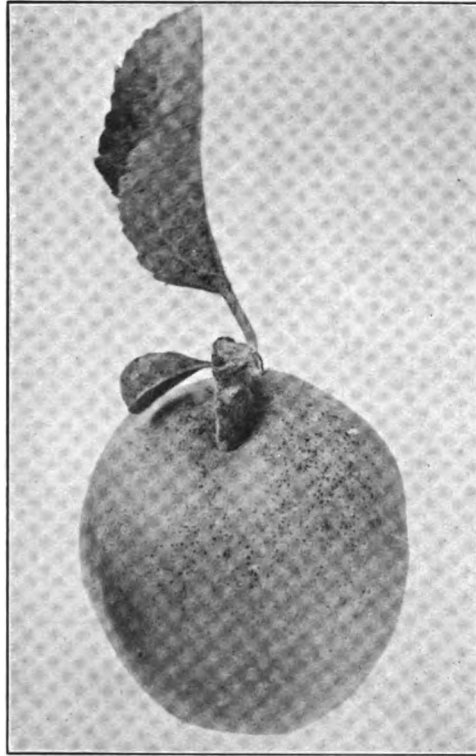


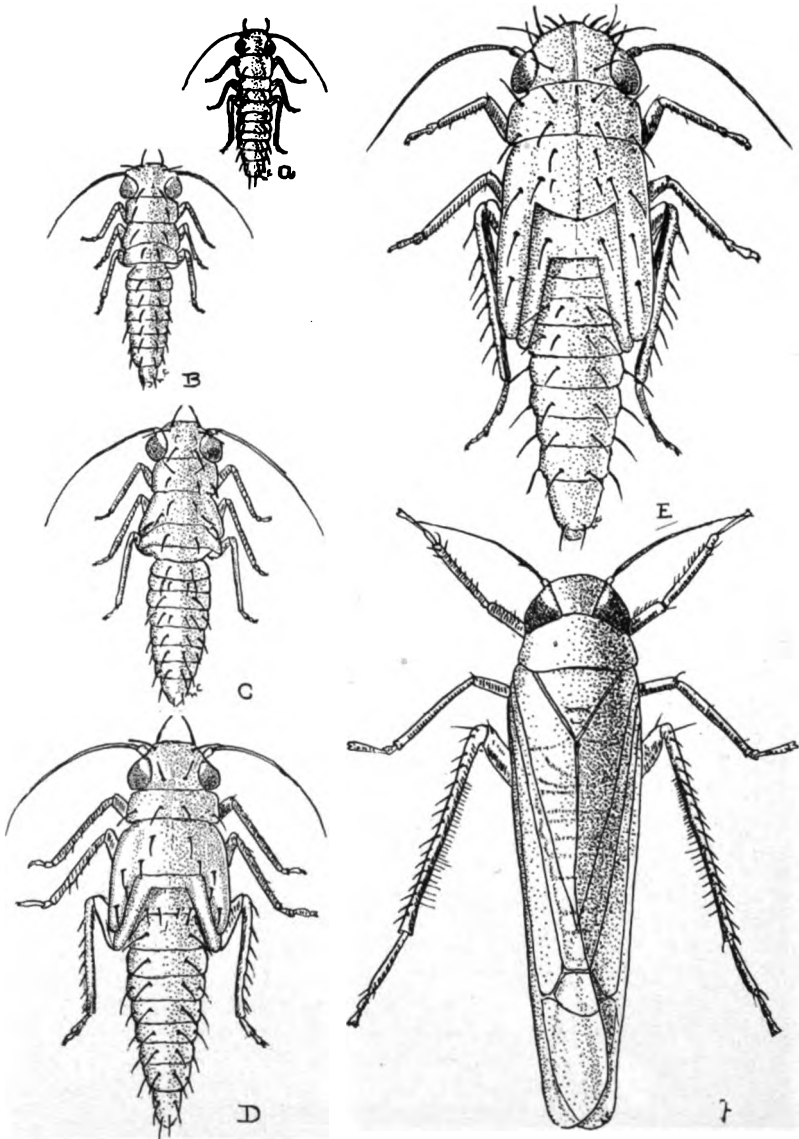
Figure 4. The only injury to fruit caused by the rose leaf-hopper is the deposition of large amounts of excrement. This gives the fruit a very dirty appearance, necessitating wiping before it can be packed.

Description of Stages

The Egg

The eggs of the rose leaf-hopper of both the fall and summer brood are very delicate, slender, decidedly elongated, and slightly curved. The end away from the egg puncture in the plant tissue is slightly larger than the other. The average length of the egg is .7 mm., width .2 mm. Within the tissues of various host plants there is considerable irregularity of shape and size. In some cases the eggs appear kidney shaped, others bean shaped, and still others with outlines like those of the oyster shell scale. This variety of shapes is

PLATE I.
DIFFERENT STAGES IN THE LIFE HISTORY
OF THE ROSE LEAF-HOPPER



(a) first stage; (b) second stage; (c) third stage; (d) fourth stage; (e) fifth stage; (f) adult insect.

probably due to the resistance offered the slender ovipositor by the plant tissues while eggs are being deposited.

The fall brood of eggs is deposited within the bark of the several food plants of this insect, while the summer brood of eggs, with rare exceptions, is deposited within the tissues on the under surfaces of the leaves of apple. The eggs in the leaves are very difficult to locate owing to the fact that they are nearly transparent and *in situ* they appear to be incorporated in the leaf tissues and are thus readily overlooked. For the most part the eggs of this brood are placed by the female along the rib and the veins of the leaves; this is not a constant behavior, however, as many eggs are inserted in the soft tissues of the leaves away from the veins and rib.

The eggs of the fall brood are easily located in the canes of rose, blackberry, and the runners of strawberry plants. In more opaque tissue, such as that of apple, it is more difficult to find them. The presence of eggs, immediately following deposition in apple tissue, is discovered only with difficulty. Their occurrence in the bark, however, must have a stimulating influence on surrounding plant cells, as in a short time a pimple-like swelling occurs. (See Fig. 7.) Swellings have not been observed on other plants in which this insect deposits eggs. The eggs are never deposited in any definite position. They are usually placed singly, with, rather than across, the grain of the tissue.

The Nymph

The young rose leaf-hopper, or nymph, when it hatches from the egg is white in color and very small. During the nymphal period the insect is wingless, increasing in size through five successive moults. With the casting of the skin the fifth time, the insect becomes winged; Plate I shows the insect in its five nymphal periods. The appearance of the insects in the different stages of both generations is practically identical.

First instar—The average length of newly emerged insects is .88 mm. Some of the larger individuals measure 1 mm. in length, while the smaller ones .71 mm. At the time the hopper leaves the egg it is more or less transparent, changing soon to almost white, and after feeding for a time becoming tinged with green. Dark red eyes and antennae longer than the abdomen are characters which enable one to separate this stage from the second. The average time required for growth in the first stage was found to be 7.3 days for the first generation and 4.1 days for the second. Eleven days was the longest period for growth of this instar noted for the first brood and four days was the shortest while nine was the maximum and two the minimum for the second brood. The insect in this stage is not active and after once finding food will scarcely move unless greatly disturbed.

Second instar—There are no marked characteristics which separate this stage from the preceding. The red coloring of the eyes has become more dull and the antennae are shorter than the abdomen. Color white, faintly tinged with green. Average length 1.34 mm. Insects of the first generation require practically twice as much time to undergo their development in this stage as those of the second; 8.5 was the average number of days for growth required by the first brood, while the second brood passed this stage in 4.4 days.

Maximum and minimum periods of growth were thirteen and six days, respectively, for the first generation; seven and three for the second.

Third instar—This stage is easily recognized from the preceding due to the slight development of the wing pads which appear on the meso- and meta-thorax and the disappearance of the red coloring of the eyes. The average length of insects in this instar is 1.6 mm. The third instar of the first generation was found to require 5.7 days; the second, four days. Eight and three days was the maximum and the minimum period for the former and seven and three for the latter.

Fourth instar—The wing pads of the leaf-hopper in this stage extend to about the middle of the third abdominal segment. These are more plump than previously noted and not shingle-like as is the case of the insect in the third stage. Insects in this stage are much more easily disturbed and show much more activity than in the former stages. The average length was found to be 2.8 mm. A period of 5.9 days was found to be the length of time required by the first brood to acquire growth, while 4.8 days was the average period demanded for development in this instar by the second brood. Maximum and minimum periods of twelve and four days, respectively, occurred with the first brood; eight and four days with the second.

Fifth instar—Wing pads have greatly increased in size, about two and one-half times as long as broad, extending to about the middle of the fourth abdominal segment. Insects in this stage are quite active and will run about when disturbed. Their movement is forward and never sideways, a means of locomotion employed by many jassids.

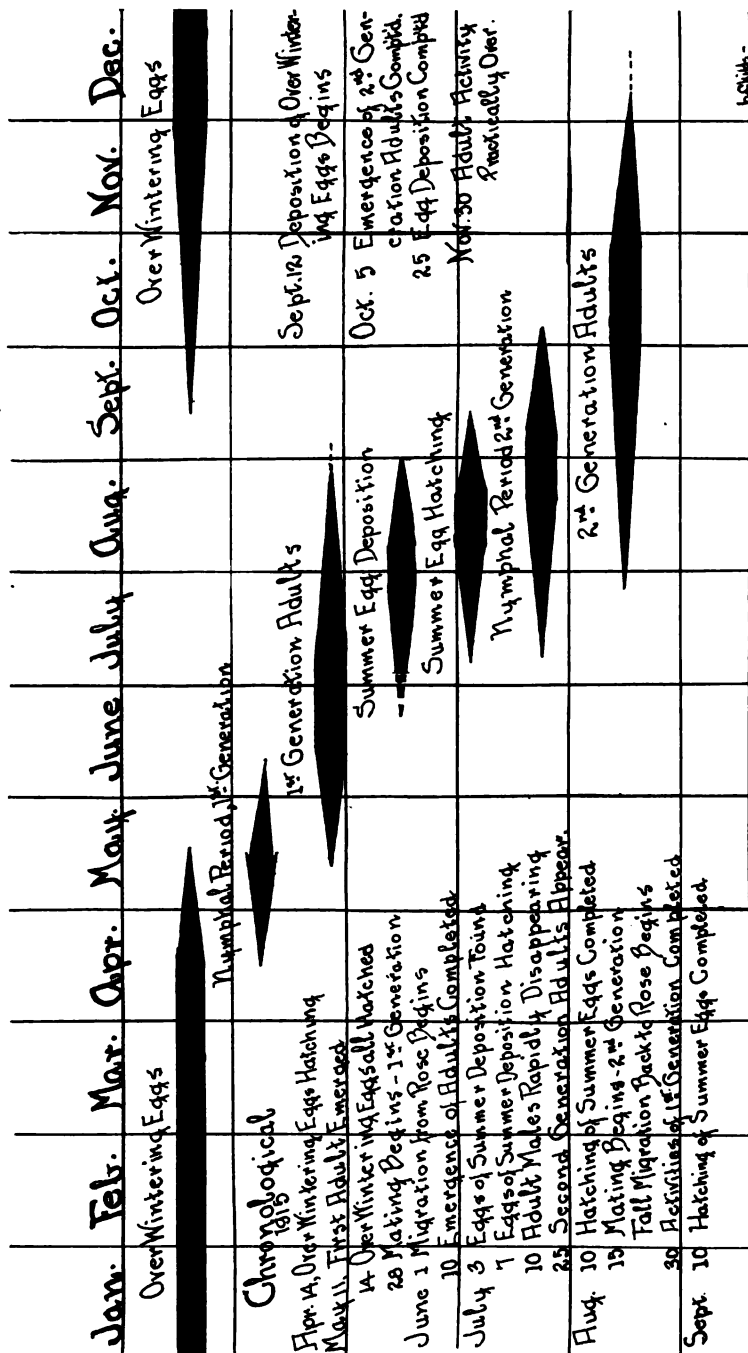
Nymphs in this period of development have occasionally been observed to jump, but this very rarely occurs. The average length is 3.1 mm. The first brood nymphs require 8.2 days to complete their development; the second 6.4. Maximum and minimum periods of the former were twelve and six days; of the latter seven and four days.

The Adult

The adult rose leaf-hopper is an active, nearly white insect measuring 3.5 mm. in length. There are practically no differences in the markings of insects of the two generations. The ovipositor of the female of the second brood is darker brown and more heavily chitinized than that of the spring form. This is undoubtedly due to the fact that the fall generation has to deposit eggs in woody tissues, while the earlier generation encounter no difficulty in the deposition of eggs in tender leaf tissue. In view of the fact that the original description by Linnaeus is lacking, the following brief characterization of this species by Harris is given:

"In its perfect stage it is rather less than $\frac{3}{20}$ of an inch long. Its body is yellowish-white, its wing covers and wings are white and transparent, and its eyes, claws, and piercer brown. The male has two recurved appendages at the tip of its hind body. It may be called *Tettigonia rosae*."

CHART I.
SUMMARY OF THE VARIOUS ACTIVITIES IN THE LIFE-HISTORY OF *EMPOA ROSAE*, HOOD RIVER, OREGON, 1915



LIFE-HISTORY AND HABITS OF THE ROSE LEAF-HOPPER

Seasonal Development

The winter is passed by the rose leaf-hopper in the egg stage. Countless thousands of these are deposited in the canes of wild and cultivated rose, evergreen blackberry, the runners of the strawberry, and to a much less extent in the tissues of other berry plants. The apple ranks low among the host plants as an egg depository of this insect.

Hatching of Over-Wintering Eggs

On April 14, 1915, over-wintering leaf-hopper eggs were found hatching on rose. On April 19 the first nymphs were observed on apple. The hatching progressed rapidly on rose, being completed by the first of May. A single first stage nymph was found as late as May 5. On apple, hatching was more gradual, due possibly to the influence of the heavier wood on incubation. This influence, through a possible reducing of temperatures in different parts of the trees, caused hatching to extend over a much longer period on apples; the last insects being found emerging on May 14.

When the time is reached for the hatching of the young hopper a bulb-like object first appears at the point of puncture in the bark which was made at the time the egg was deposited. This bulb continues to grow and on the side, about .2 mm. from the blunt tip, will be noticed a conspicuous red blotch. These blotches occur on either side of the white sack and are the compound eyes of the fully developed embryo. No visible motion can be detected on the part of the encased insect during the first part of its emergence. Just what force drives this smooth body forward seems to be a matter of conjecture. After the body is about one-third out, however, a distinct pendulum-like movement occurs. In this way the insect takes advantage of the ridges of the body segments and the stiff hair-like bristles. Each movement causes a lifting up and out of the insect which, still encased in the shell, stands out nearly perpendicular to the stem, attached only by the tip of the abdomen. The splitting of the shell does not occur until the encased insect is entirely free from the plant tissues. Splitting takes place along a median line in the head region. The first indication that this has occurred is a popping out of the bristle-like spines that are present on the front margin of the head. Their arrangement seems to indicate that they are used in causing this break. Following the splitting the escape of the insect is quickly accomplished. A movement much like that which brought the embryo out of the plant tissue occurs; large spines found in many parts of the body assist in driving the body forward. In rapid succession, head, thorax, and abdomen become free; for a few moments the newly emerged insect stands erect, held up by the tip of the abdomen. Finally violent wriggling occurs, the insect bends over to the stem, brings its legs into action, and frees itself from the remaining shell attachment. The entire process of emergence requires about twenty minutes.

Following a short rest, the young insect begins wandering about in search of a leaf; this found, the hopper establishes itself on the under side and begins

feeding at once. If plenty of food is available the insect will pass its entire nymphal development on this leaf.

Emergence of Adults and Migration from Rose

On May 11, 1915, the first adult leaf-hopper was found to have emerged. This was an exceptionally early form. Winged leaf-hoppers were found in

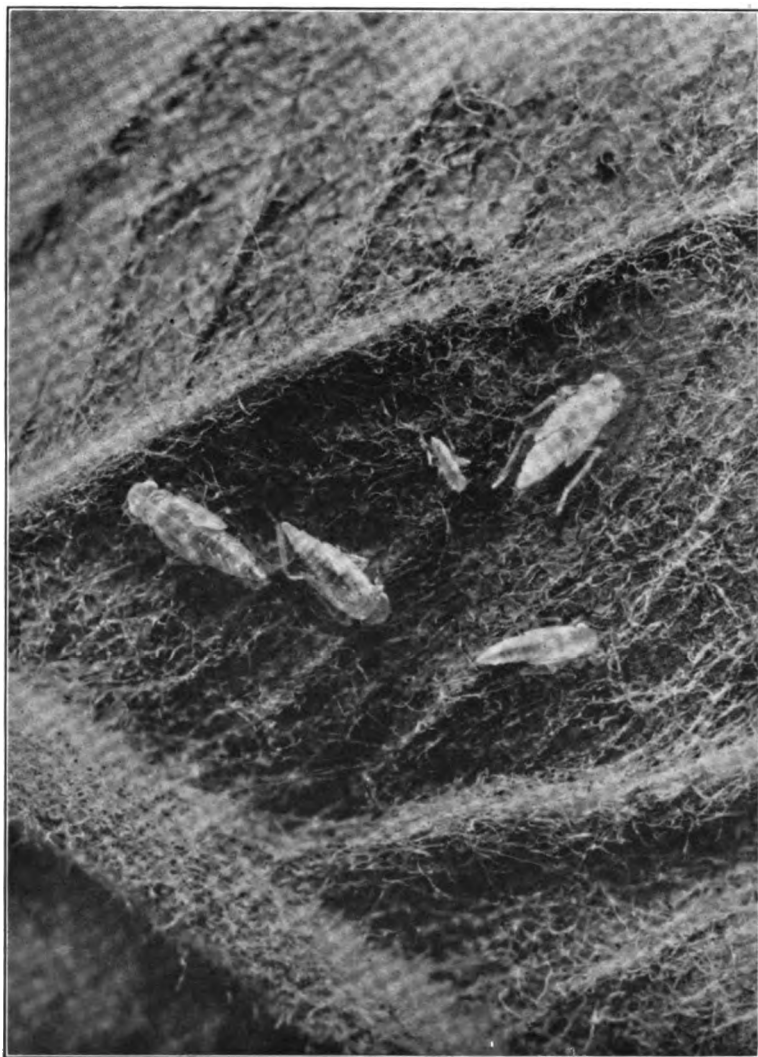


Fig. 5. Nymphs of the rose leaf-hopper feeding on the under surface of an apple leaf (much enlarged). Third, fourth and fifth stage insects are present.

large numbers May 20, and by June 10 practically all had reached the adult stage. Infested roses were observed to be severely devitalized by this time, practically all of the foliage being yellow. In this condition little available food is present and the winged hoppers migrate from this plant to the summer food plant, apple.

In 1915 the hoppers began to migrate from the rose about June 1. On June 6, 1915, they were observed leaving in large numbers, especially in the evening, when the air seemed to be full of the flying insects. On June 8 very few hoppers remained on the rose bushes, and a very natural increase in the number of insects present on apple was noted.

Mating of First Generation Insects

Pairs of the rose leaf-hoppers were first found in copula on May 28 on apple foliage. From this date on to about June 20 mating pairs were very

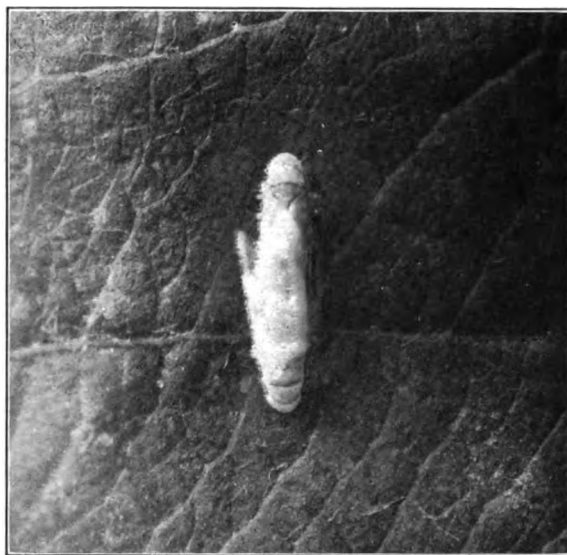


Fig. 6. Mating rose leaf-hoppers (much enlarged).

plentiful; after that date few were noted. Mating is much more free in the morning than at any other time of the day and is only rarely observed during the warmer hours of midday. Mating pairs rest with the tips of their abdomens together (See Fig. 6) and the heads in opposite direction. They remain in this position for one to two hours.

Egg Deposition and Hatching of Summer Brood

The deposition of eggs of the summer brood has never been observed. The adult insects are extremely active, recognizing an intruder at a distance of at least ten or twelve feet, and manifesting great consternation throughout

the tree when it is approached. This activity probably accounts for the fact that egg laying has never been noted. Daily observations for hopper eggs on the leaves were begun on June 14, 1915, and continued until July 3, when a few eggs were found along the mid rib of an apple leaf. After this date eggs were readily found.

Egg laying of the summer generation of insects occurs throughout the greater part of July and August; towards the latter part of August, however, insects become fewer in number and practically disappear by the first of September. The male adults do not live long after mating. The proportion of this sex present on the apple trees rapidly decreases after July 10.

Summer Brood of Nymphs

The first nymphs of the second generation began hatching on July 7, 1915, hatching continuing to increase until August 10 (See Chart 3), decreasing rapidly until August 23, when, with the exception of a few stragglers, it had practically ceased. Hatching of the summer eggs takes place in the same manner as that reported for the spring brood. The young nymphs immediately begin feeding upon the leaf from which they hatch and here undergo the development which takes them to the adult or winged stage. Under normal conditions no wandering from leaf to leaf occurs. The changes which take place during this development are identical with those given for the first brood. The average time required for nymphal development is somewhat shorter than for the spring brood.

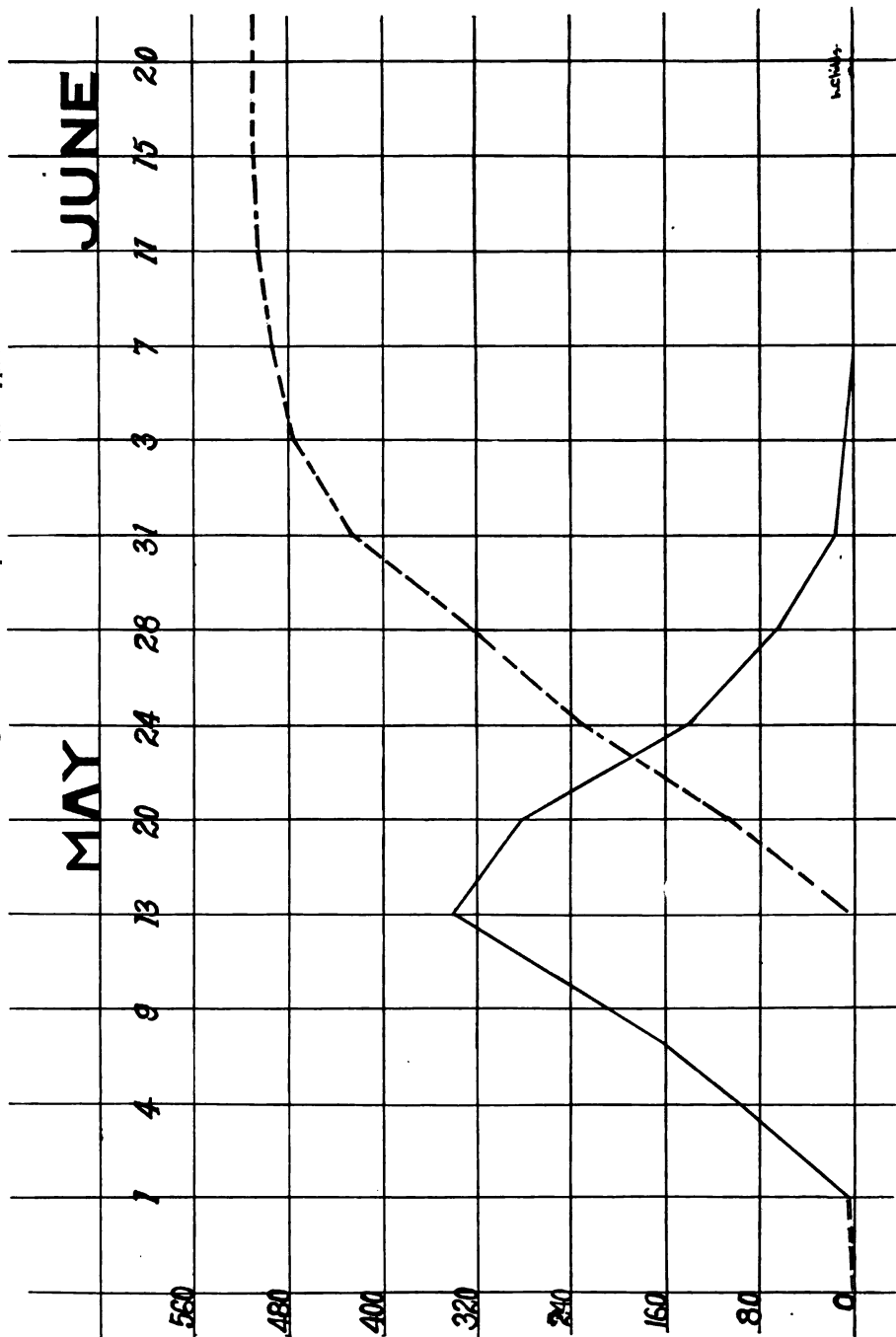
Life-History Study of Nymphal Period

The length of the five nymphal periods has been determined through a study of thirty individuals of the first brood of 1915; thirty-three individuals of the second brood of this same year, and fourteen individuals of the later-appearing insects of the second brood in 1914. Breeding experiments were conducted in cheese cloth bags containing a single apple leaf. Owing to the fact that it was very difficult to detect eggs without the use of the binoculars, the usual method employed to capture the newly emerged nymph was to bag leaves on severely infested trees, removing the hoppers daily from these as they hatched. The hoppers in turn were bagged separately. These were examined daily and their development recorded until they changed to the adult stage. Little trouble was encountered in the rearing study, as nymphs during a greater part of their development are quite inactive and easily handled.

Habits of the Nymphs

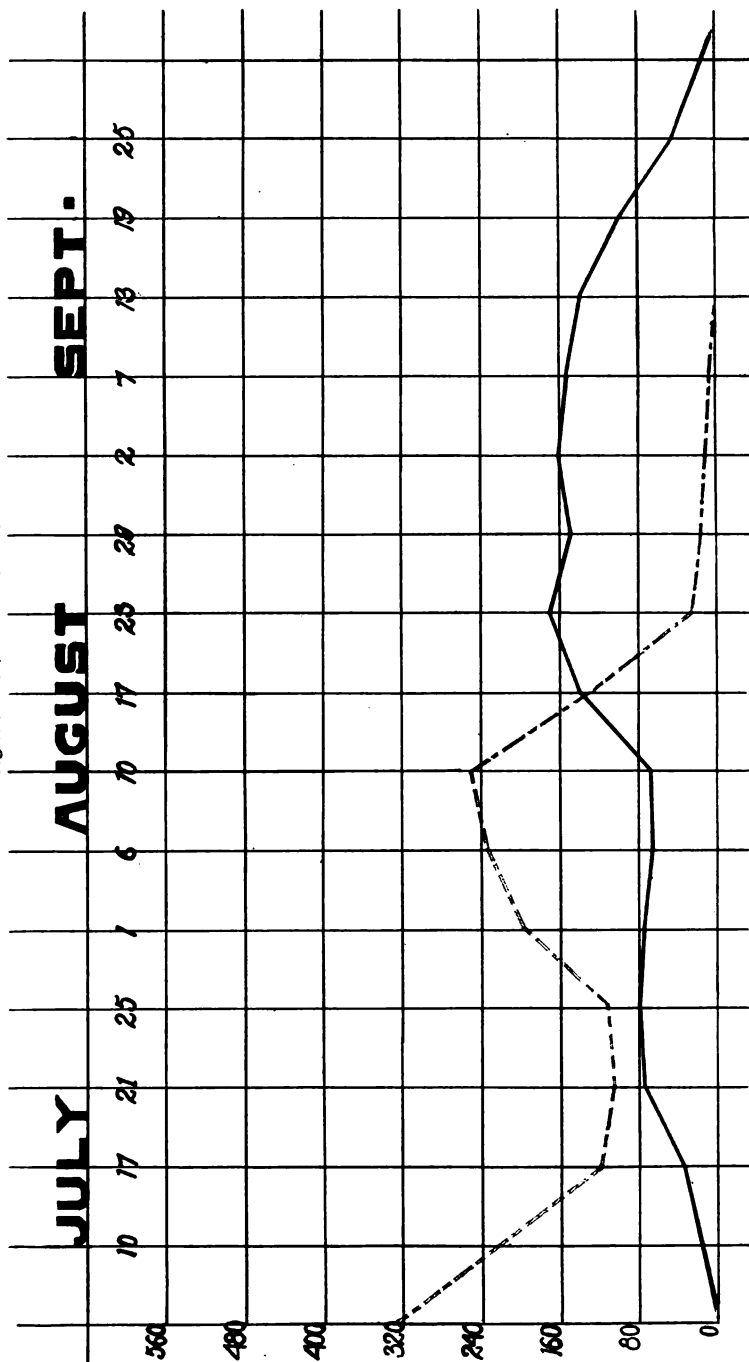
During their growth they usually seek protection by nestling down along the mid rib of leaves or in the surrounding heavy pubescence rather than attempt to run away when disturbed. The nymphs in their various stages have a peculiar habit of discharging excreta upon being disturbed. The abdomen is arched and the anterior part brought forward with a quick jerk, whereupon a small globular bit of excreta will be thrown out at a distance of from one-half to an inch from the insect. Whether this is used as a form of defense against preying insects was not determined. No disagreeable odor is present even where the insects occur in large numbers.

CHART II.
FIRST GENERATION DEVELOPMENT
—— Progression of fourth instar insects
----- Progression in the development of adult leaf-hoppers



These lines represent the numbers of insects present, based on a miscellaneous count of 500 individuals taken at intervals of from three to six days until all had reached the adult stage. Fourth instar insects began to appear on May 1; the ratio gradually increased until May 13. Adults began to appear May 11, their proportions gradually increased until June 15 when practically all were found in this stage. Other stages are omitted for the sake of clearness.

CHART III.
SECOND GENERATION DEVELOPMENT
—— Progression of fourth instar insects
== == Progression of first instar insects



The development of the second generation is longer drawn out and less distinct than the first. When the counts were first started practically all of the insects were in the first stage (double line). Progression into the other stages materially affected this graph until July 25. The percentage of first instar insects increased rapidly after this date until August 10, following which hatching rapidly dropped off. Fourth stage insects were present during a greater part of July, August and September. They were found most plentifully on August 23.

TABLE II. NYMPHAL PERIODS OF THE FIRST BROOD OF *EMPOA ROSAE*, MAY AND JUNE, 1915, AT HOOD RIVER, OREGON

No.	Date of Hatching	First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar	Total Nymphal Period
		(days)	(days)	(days)	(days)	(days)	(days)
1	May 7	4	10	8	5	8	35
2	" 12	8	8	3	5	8	32
3	" 11	6	7	6	9	5	31
4	" 7	7	8	7	12	6	37
5	" 7	5	10	6	6	6	33
6	" 11	11	9	4	6	9	39
7	" 7	5	9	7	4	12	37
8	" 7	7	12	6	5	8	38
9	" 14	7	8	4	5	6	30
10	" 14	9	7	5	5	11	37
11	" 10	7	6	6	7	8	34
12	" 9	10	9	6	4	10	39
13	" 10	6	13	4	4	9	36
14	" 11	10	8	6	4	9	37
15	" 9	6	9	6	6	8	35
16	" 9	7	7	7	6	8	35
17	" 9	6	7	7	7	8	35
18	" 9	8	10	3	6	8	35
19	" 9	8	8	7	5	7	35
20	" 12	8	8	6	5	9	36
21	" 11	7	9	4	6	8	34
22	" 9	7	8	7	6	9	37
23	" 9	4	9	7	7	7	34
24	" 9	7	7	6	7	10	38
25	" 9	9	9	5	5	7	35
26	" 9	8	9	6	5	9	37
27	" 9	8	9	5	6	9	37
28	" 9	9	8	5	6	9	37
29	" 9	8	7	5	8	8	36
30	" 9	8	7	7	6	8	36
Average		7.3	8.5	5.7	5.9	8.2	35.6

Variation of Length of Nymphal Periods of the Two Generations

The average period required for nymphal development of the first generation of the rose leaf-hopper was 35.6 days in 1915. With the earlier forms or main brood of the second generation, a period of 23.7 days was demanded for growth. Later forms (August and September) of the second generation required a period of 34 days. Temperatures affect the nymphal development of the insects while they are in this immature stage. A wide variation was found to exist in the length of the nymphal stages of insects hatching at the same time. It was observed, however, that in cases where one insect would be tardy in acquiring its growth in one instar, it would be more speedy in some others, making the averages fairly uniform. In the first generation 39 days was found to be the longest time required to reach maturity, 30 days being the shortest. In the early forms (hatched in July) of the second brood, 28 days was found to be the maximum and 20 days the minimum for nymphal growth. A much greater variation occurred in the development of insects which hatched during the latter part of August. Forty days was found to be the maximum; 21 the minimum. Of the fourteen individuals studied, however, but four required less than 30 days to complete their development. Tables II, III and IV give a daily record of development of insects used in this study.

Casting of Nymphal Skin

When the time arrives for the full-grown nymph to change to the adult insect, the first act performed is that of firmly setting the claws into the leaf

TABLE III. NYMPHAL PERIODS OF THE SECOND GENERATION OF *EMPOA ROSAE* JULY AND AUGUST, 1915, AT HOOD RIVER, OREGON.

No.	Date of Hatching	First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar	Total Nymphal Period
1	July 8	5	6	4	5	6	26
2	" 9	9	4	3	4	6	26
3	" 9	3	5	5	5	7	25
4	" 18	5	3	3	6	6	23
5	" 9	4	5	5	5	11	30
6	" 17	3	4	7	4	4	22
7	" 9	3	7	3	5	5	23
8	" 18	3	3	5	5	6	22
9	" 9	5	6	4	4	4	27
10	" 9	5	3	4	6	6	24
11	" 28	4	6	4	4	9	27
12	" 24	5	3	3	4	5	20
13	" 15	4	6	3	4	5	22
14	" 17	4	4	5	6	6	25
15	" 8	5	3	4	5	6	23
16	" 16	5	3	4	5	7	24
17	" 8	5	6	3	5	7	26
18	" 14	3	4	3	6	7	23
19	" 8	6	6	5	5	6	28
20	" 8	3	4	5	4	7	22
21	" 16	2	4	3	6	7	22
22	" 8	3	4	3	5	7	22
23	" 8	6	5	3	5	6	25
24	" 8	4	6	4	4	7	27
25	" 16	3	5	4	8	7	26
26	" 8	2	7	4	4	9	26
27	" 8	4	3	5	5	7	24
28	" 13	5	3	5	6	6	25
29	" 20	2	5	4	6	6	23
30	" 17	4	3	4	4	6	21
31	" 16	3	3	5	4	7	22
32	" 17	4	3	3	6	6	22
33	" 11	6	4	3	5	7	25
Average		4.1	4.4	4.0	4.8	6.4	23.7

TABLE IV. NYMPHAL PERIODS OF THE SECOND GENERATION OF *EMPOA ROSAE* IN LATE SUMMER, AUGUST AND SEPTEMBER, 1914, AT HOOD RIVER, OREGON.

No.	Date of Hatching	First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar	Total Nymphal Period
1	August 20	3	7	7	10	15	41
2	" 27	4	5	8	10	11	38
3	" 14	5	4	2	6	11	28
4	" 18	5	2	3	6	17	33
5	" 20	2	8	5	12	15	42
6	" 15	3	4	4	5	5	21
7	" 14	5	5	4	6	15	35
8	" 19	5	5	5	9	15	39
9	" 18	5	4	5	10	13	37
10	" 13	2	5	6	3	12	28
11	" 12	4	4	4	4	9	25
12	" 16	5	5	4	7	16	37
13	" 21	6	4	4	12	5	31
14	" 21	6	4	6	13	12	41
Average		4.3	4.8	4.7	8.0	12.2	34.0

tissues. This always takes place on the under surfaces of the leaves. After the claws are firmly set the insect remains quiet for some time. The wing pads gradually become swollen, standing slightly away from the body of the insect. A split finally occurs along the median line of the dorsum, extending through the head and thoracic regions. Soon after the splitting of the old skin takes place, an up and down movement, bending away and toward the leaf, is carried on by the emerging imago. Each one of these movements, through the aid of the coarse spines on the body and legs of the insect, drives

it forward from the old skin. The insect keeps all of the legs folded under the body until all are free. The movement continues until only the tip of the abdomen remains attached to the old skin. The legs are then straightened out and the joints tried several times before the insect's body bends down to the leaf surface. The young adult hopper then grips the leaf surface, pulling the remaining portion of the abdomen free from the old skin. The wings at the time the newly emerged adult makes its appearance are merely small ball-like appendages located on the sides and posterior parts of the thorax. The covers or outer wings are the first to expand and are quite often found to be wellspread before the insect leaves the old skin. Before the wing covers are completely expanded the under wings begin to unfold, assuming a normal position in about twenty minutes. Insects have been made to fly within an hour's time after the beginning of the moult. Under normal conditions, however, they show no inclination to make use of the wings and will remain quiet for several days.

The casting of the skin of the earlier stages was found to be the same as that described for the last moult, with the exception that the claws are not driven so far into the plant tissues. All cast skins, with the exception of those of the last moulting, drop from the under side of the leaves. This last skin never drops. Moulting of the earlier stages requires a period of from fifteen to thirty minutes.

Longevity of Mated Females—First Generation

On May 10 a number of mating pairs of the rose leaf-hoppers were placed in individual cheese cloth bags on apple foliage, in order to determine the number of progeny that would result from the matings. Owing to the fact that there was danger of destroying or permitting the escape of the insects, the bags were only examined at intervals of about two weeks. The irregularities that happened due to the presence of several predaceous insects in several of the bags, together with the dropping of many leaves in others, probably destroyed even an approximation of the number of individuals resulting from a single pair of leaf-hoppers. The caged insects produced an average of but 12.7 insects, the maximum progeny of a single female being 27 insects. These figures are believed to be much lower than the average which normally occurs.

In connection with this study, it is interesting to note that the life of the male hopper is not continued long after copulation. Several were found dead four days after mating and the remainder were all dead when the cages were examined ten days later.

Nymphs of the first stage were found for the first time in the breeding cages on July 20, 40 days after the mating pairs were placed in the bags, but one of the nymphs had reached the second stage in its development.

With the exception of one individual, No. 4, which produced twenty-seven progeny, the other females were found to be dead on July 10, one month after they were placed in the bags. On July 20 the last caged female died. From the data at hand, gravid females live from one month to a month and a half following mating.

Longevity of Unmated Leaf-Hoppers—First Generation

The length of life of mated egg-laying females was found to be much shorter than that of the unmated insects. One individual was kept under observation from the time of hatching, May 7, until August 30, or 116 days. Death at this time was due to starvation, as the leaf upon which it was feeding dropped from the tree.

Others were kept under observation 70 days, following which, a few days later, the leaves fell, resulting in their death.

The life of the unmated male is much shorter. None of those used in the life-history study were found to be alive July 10, 1915.

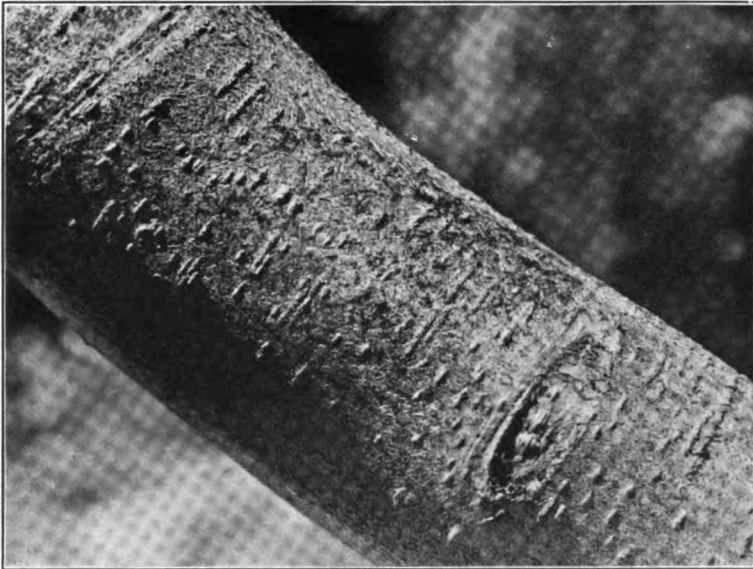


Figure 7. Overwintering eggs in five-year-old apple limb. From some of these pimples insects have emerged in previous years. Others contain egg parasites from which few can make their escape in bark of this age.

Time of Mating of Second-Generation Insects

The first mating pairs of leaf-hoppers of the second generation were found August 15, 1915. Mating, however, did not reach its height until about the middle of September, gradually becoming less noticeable. Occasional mating pairs have been observed late in October.

The fall migration of the insects from the apple back to the rose began in 1915 on August 14. This migration is much more gradual than the departure of the insects from the rose in the spring. The leaf-hopper inhabitants of the rose bushes gradually increase in number until the bushes are literally swarming with the active creatures. During this time the bushes are again subjected to a severe devitalization through the loss of food properties and chloro-

phyll, which, following the severe spring injury caused by the nymphs of the first generation often render the plant unfit for flowering the following spring.

Deposition of Over-Wintering Eggs

The deposition of over-wintering eggs was first noticed on September 12, 1915, on both apple and rose. This activity continued throughout the fall, reaching maximum deposition during the middle of October at which time the canes of roses were found lined with leaf-hoppers with their ovipositors deeply embedded in the soft green bark of this plant. Egg-laying insects are found with much more difficulty on apple. The time for egg laying on this plant seems to be confined to early morning and late in the evening. During damp, cloudy days the insects will be found depositing eggs during mid-day; this never occurs on bright sunny days. Egg laying is much more free mornings and evenings on rose, but nevertheless insects can be found so engaged at any hour of the day, and very often at night, on this plant.

Longevity of Second Generation Insects

The second generation of adult leaf-hoppers appears to be much more hardy and long lived than the first generation. And in the case of the females death seems to be traceable for the most part to the reduction of food and the severity of the cold wet winters. In the breeding experimental work adult insects, which hatched during early August, were kept alive until December 10. They were destroyed at this time by a heavy snow which crushed down the bags located on rose bushes. In 1917, a very mild fall occurred, and adult leaf-hoppers could be easily found on rose bushes at late as December 20. A great majority of the insects were dead, however, by the first of December.

Location of the Over-Wintering Egg

Practically all of the eggs deposited on the canes of rose and the other bush fruits which serve as food plants of this insect are placed in the tissues that have made their growth during the summer immediately following egg deposition. This, however, is not the case with the apple, as insects have been observed laying eggs in bark up to eight years of age. Only rarely, however, is the bark of apple in such condition at this age as to be suitable for egg deposition of this insect. For the most part eggs are not often found in bark older than five or six years. The following figures (See Table V) show the percentages of deposition in bark of various ages up to four years. These figures were taken from apple of the Newtown variety.

TABLE V. EGG DEPOSITION IN NEWTOWN APPLE BARK

Age of Wood	No. Eggs Counted	No. Sq. Inches Observed	No. Eggs Per Sq. Inch
4	96	21.9	4.3
3	564	130.4	4.3
2	371	93.4	3.9
1	495	76.1	6.7

From the figures given in Table V it would appear that the current year's growth was the more favorable for egg deposition. This seems to be true of the Newtown variety only, as in both Spitzenburg and Bellflower fewer eggs

were found in the one-year-old wood than in the wood of other ages examined. Table VI gives the location and the average number of eggs found per square inch of bark surface of the three varieties—Newtown, Spitzenburg, and Bellflower. The egg counting was all done in the laboratory where the binocular microscope was used in locating the eggs in the plant tissues. The fact that branches of over four years of age were not available for the study, prevented an investigation of the older bark tissue.

TABLE VI. DISTRIBUTION OF EGGS IN DIFFERENT AGED GROWTH OF APPLE BARK. (NEWTOWN, SPITZENBURG, BELLFLOWER.)

Age of Wood	No. of Eggs Counted	No. Sq. Inches Examined	No. Eggs Per Sq. Inch
4	96	21.9	4.3
3	850	200.7	4.2
2	633	162.	3.9
1	631	163.4	3.8

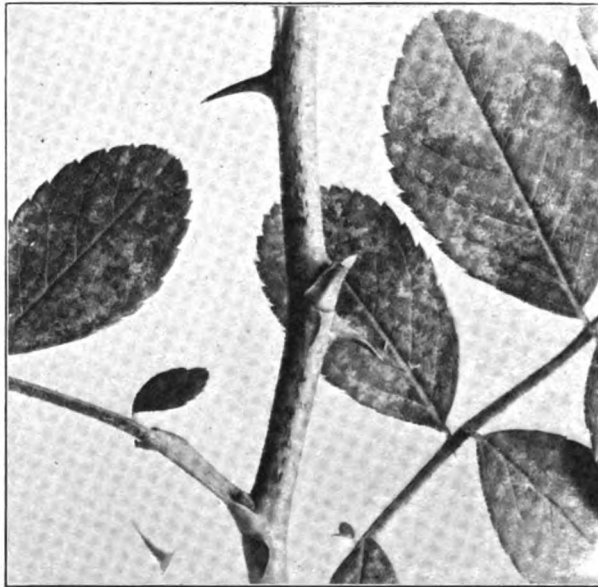


Figure 8. Rose twigs showing 577 eggs to the running inch. The mechanical injury to the stem is often severe. A fungus disease has been observed entering these punctures.

The Rose—The Principal Over-Wintering Egg Depository

In order to determine the ratio of egg deposition and its bearing upon the control of this insect in the various food plants, a locality was chosen in which practically all of those used by this insect were found in close proximity. This study was carried on in an area not to exceed an acre in extent, making it possible for the insects to choose (without being influenced by the scarcity of any of its host plants) any one of the five or six principal plants used for egg

deposition. The rose was found to be much more favored by this species than the other plants as an egg depository. Basing percentages on numbers of eggs to the square inch of bark surface, it was found that 92.7% of the over-wintering eggs were placed in the new growth of rose stems. Astonishing numbers of eggs were found present, as shown in Table VII; 6,924 eggs were noted in 6.7 representative square inches of bark surface. The eggs were found so close together that in many cases they were touching; occasionally one would occur beneath another in the soft tissue of the stems. Figure 8 shows a rose twig $\frac{3}{16}$ inch in diameter upon which were found 577 eggs to the running inch.

This pronounced preference for the rose as compared to the other host plants makes it possible to use this plant successfully as a trap crop in order to reduce the number of hoppers.

Only 7.3% of the fall deposition of eggs was found on all of the other host plants combined. Runners of strawberry plants were found to be the next choice of the hoppers with a percentage of 2.7. This was followed by evergreen blackberry with 2%; cultivated blackberry, .84%; raspberry, .7%; Newtown apple, .4%. With the possible exception of the strawberry, infestation resulting from the hatching of these percentages of eggs, would not cause serious injury to the plants.

TABLE VII. OVER-WINTERING EGG DEPOSITION OF *E. ROSAE* IN LOCALITY IN WHICH ALL OF THE PRINCIPAL FOOD PLANTS WERE PRESENT

Host Plant	No. of Eggs Counted	No. Sq. In. Bark Surface Examined	No. Eggs Per Sq. In. Bark Surface	% of Total Deposition
Rose (wild sweet)	6924	6.7	1030.	92.7
Strawberry	519	17.3	30.	2.7
Blackberry (evergreen)	282	12.5	22.5	2.0
Blackberry (cultivated)	173	18.4	9.4	.84
Raspberry	104	13.3	7.8	.7
Apple—				
Newtown	1208	266.5	4.5	.4
Spits	176	54.7	3.2	.28
Bellflower	394	122.4	3.2	.28

Attempt to Rear Third Generation

In view of the fact that nymphs were found present on apple foliage during late summer and early fall, experiments were conducted to discover whether a third generation of insects occurred. To determine this point several of the earliest mating pairs of the second generation were captured and caged on the foliage of both apple and rose. No mating pairs of the second generation were observed until August 18. In none of these cages were nymphs found during the fall. On September 15 several over-wintering eggs were observed on the stems of a rose in one of the cages.

In another cage enclosing apple foliage, several males and females, the progeny of the caged females of the first generation, were placed on August 20. This cage was examined at intervals during the remainder of the summer and fall, but no more nymphs were found on the foliage. Considering that development of the earliest mating individuals of the second generation occurred as rapidly as that of the second generation, nymphs could not be expected until about October 1, and no hatching leaf-hoppers have been observed at this time of the year. The experimental data and field observations at hand demonstrate that there are but two generations of this insect a year.

Parasitic and Predaceous Enemies of Rose Leaf-Hopper

The rose leaf-hopper does not suffer to any great extent from the attack of predaceous and parasitic enemies. The only enemy which plays an important part in the economy of this species is a very minute hymenopterous egg parasite, *Anagrus armatus*, which has been observed to destroy fully one-third of the eggs of this leaf-hopper. The parasite passes the winter within the egg of the leaf-hopper. Fresh emergence holes have been found in early June. In 1915 the first adult insects were found on July 7. During the latter part of the month they were observed in numbers wandering over the under surfaces of the apple leaves in search of eggs of the summer brood of hoppers. During August and the early part of September the parasites were not numerous but during the latter part of September and throughout October many of the insects could be found working over plants containing eggs of the leaf-hopper.

This minute insect is exceedingly ungainly in appearance. The wings are nearly one-half again as long as the body and fringed with proportionately long hairs; the insects wander over the egg-infested twig surfaces, stroking the bark with their antennae. When a suitable location is found the ovipositor is inserted through the wound made in the plant tissue by the female leaf-hopper. While depositing eggs the parasite remains over the hopper egg for several minutes, during which time the wings extend at almost right angles to the body. Often these parasites, especially those located in the older wood of apple, die within the tissues of the plant being unable to emerge through the thickened bark. Many of the leaf-hopper eggs shown in Figure 7 contain adult parasites which were unable to emerge and have died. With the exception of those insects undergoing development in apple, little trouble is encountered by the parasites in making their escape.

Predaceous Enemies of the Nymph

There are several predaceous insects which feed upon the nymphal leaf-hoppers. *Chrysopus californicus*, the green lacewing, destroys more leaf-hoppers than any of the other insect enemies kept under observation. Unfortunately this species is not plentiful and but limited benefits are derived from its activities. The brown lace-wing, *Hemerobius pacificus*, also attacks the nymphs of the rose leaf-hopper, but it too is only rarely found on infested apple trees.

It has been observed that both of these species find it difficult to catch their victims, owing to the fact that their power of vision and activity is much less than that of the leaf-hopper. When once captured, however, the hopper never escapes. The capture of a fourth-stage nymph by a green lacewing larva was observed; but six minutes was required in extracting all of the body juices, even the pigmented fluid of the eyes was drawn out entirely. *Triphleps* sp. and the larva of a predaceous Thrips was found destroying many nymphs of the first and second stages. The two, however, are only occasionally present.

Predaceous and Parasitic Enemies of the Adult

Only one true parasite of the adult insect has been observed. This is a Dryinid, a parasite which is only seldom met with. Adults of both the first and second generations have been found to be attacked by this parasite. Par-

asitized leaf-hoppers are much less active than those unattacked. Before dying they often attach themselves to the under leaf surfaces, much like the fifth nymphal skin, and remain there until the leaf falls. The parasite, at the time of the death of the host or shortly thereafter, drops to the ground in the form of a legless grub. Nothing further is known relative to the life-history of this beneficial insect, as all attempts to rear it have failed.

Spiders play a small part in the control of adult leaf-hoppers, destroying many in their nests. Among these are several species*; *Agelena pacifica* Bks., *Epeira trifolium* Htz., *Epeira displicata* Htz., and *Dendryphantes* sp. Of these several spiders *A. pacifica* is the more common. It spins a large fan-shaped web in which many winged leaf-hoppers are ensnared.

In orchards near streams large dragon flies have been observed catching the winged leaf-hoppers. These insects, however, have only been rarely observed attacking the hoppers. *Scatophaga merdaria*, a common scatophagid fly, has often been observed catching and eating the adult leaf-hoppers.

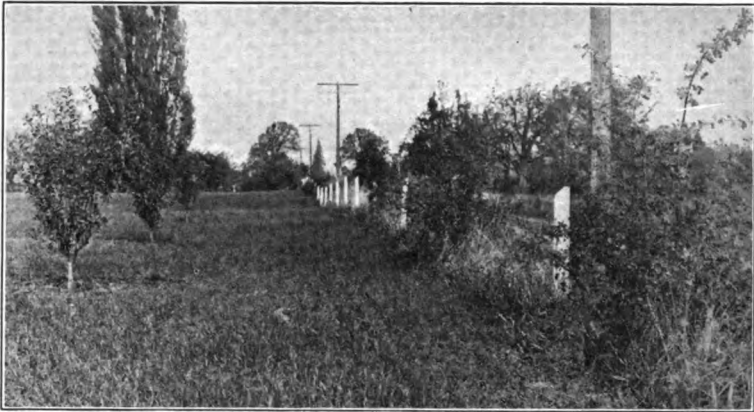


Figure 9. Hedge of wild sweet rose adjoining young apple orchard. Countless thousands of eggs are deposited in the canes of these bushes each fall, while practically none are found in the adjoining apple trees.

Control Measures

The rose as a trap crop. The very marked affinity shown by the egg-laying female for the rose, both cultivated and wild, offers a medium through which this insect can be controlled. From the figures which have been obtained, Table VII, based on the number of eggs deposited per square inch of bark surface, it has been found that 92.7% were deposited in rose canes and but 7.3% in all of the other plants combined. These figures were obtained in a locality where all of the plants used by the egg-laying females were in close proximity. The percentage found deposited in the twigs of apple was but .4%.

The proper treatment of roses, used as a trap along fences near the orchard, either in the form of an application of spray or by pruning before the adult stage is reached, is believed to be a very satisfactory method of keeping the insects reduced to a minimum in the apple orchards. Figure 9 shows a rose hedge along one side of a young apple orchard. In the fall of 1915 these bushes

*Determined by Nathan Banks.

were literally swarming with hoppers, busily depositing eggs, while it was difficult to find hoppers or eggs on the adjoining apple trees. In one of the rose bushes a young seedling apple tree was found growing. Several twigs from this tree were examined under the binocular microscope for eggs, and not a single one was found. This relationship of rose and apple to the fall egg deposition was made the object of a study in many places and in every case very few hoppers were found on the trees near rose bushes.

Spraying Experiments—Several insecticides were tested out to determine the most effective spray to be used for the control of this insect. These included Black leaf forty, in different strengths, soap and water, and lime-sulfur solution 1-25. Table VIII gives the results obtained from the use of these different materials. Experiments No. 1, 3, and 4 were applied May 9, 1916, shortly after which a thunder shower of considerable extent occurred. This perhaps affected the results that are tabulated, as the dilution resulting from the precipitation might have altered the effectiveness of the materials somewhat, especially in No. 1, where poorer results were obtained than in No. 2, regardless of the fact that the tobacco was used at a much weaker dilution. Experiments No. 2 and 5 were applied the following day, May 10. At the time the applications were made few of the insects were further advanced in their development than the third stage. A majority of them were in the first and second instars. Good control was obtained in all of the experiments. The

TABLE VIII. RESULTS OF SPRAYING EXPERIMENTS FOR THE CONTROL OF THE ROSE LEAF-HOPPER. MAY 9 AND 10, 1915.

Exp. No.	Materials	Strength	Insects Alive	Insects Dead	Percent Killed
1	Black Leaf 40 Soap	1-1200 5 lb.-100 gals. Water	38	741	95.0
2	Black Leaf 40 Soap	1-2000 5 lb.-100 gals. Water	4	600	99.0
3	Whale Oil Soap	20 lb.-100 gals. water	11	735	98.5
4	Whale Oil Soap	10 lb.-100 gals. water	59	500	89.6
Unsprayed Check			600	5	.8

most effective destruction of the hoppers was obtained in Experiment No. 2, where Black leaf 1-2000, plus five pounds of soap to one hundred gallons, was used. The results obtained in Experiment No. 5, however, are more significant. During 1913 and 1914 it was observed that in nearly every case insects were much more numerous in the young orchards than on the old bearing trees, the reason for which fact could not be determined at that time. Young non-fruited orchards are seldom sprayed, with the possible exception of the dormant application, while in the older orchards, in order to effect scab control it is necessary to spray several times during the spring and early summer. Lime-sulfur is the universal fungicide employed for this work. The so-called ten-day and thirty-day lime-sulfur sprays which are usually applied during the latter part of May or early June, occur at a time when the leaf-hoppers are in their younger nymphal stages, and have proved very effective in reducing the numbers of the first generation of insects.

In 1917, owing to the fact that the season was very tardy, the thirty-day application of lime-sulfur was generally omitted throughout the Hood River valley. As a result the numbers of the first generation of leaf-hoppers were relatively large; this, together with the great numbers of insects migrating from the rose, produced a summer generation which proved injurious in many orchards. In these orchards control measures would have been advisable.

Owing to the fact that the nymphs confine their activities to the under surfaces of the leaves it is necessary to spray from below in order to wet them

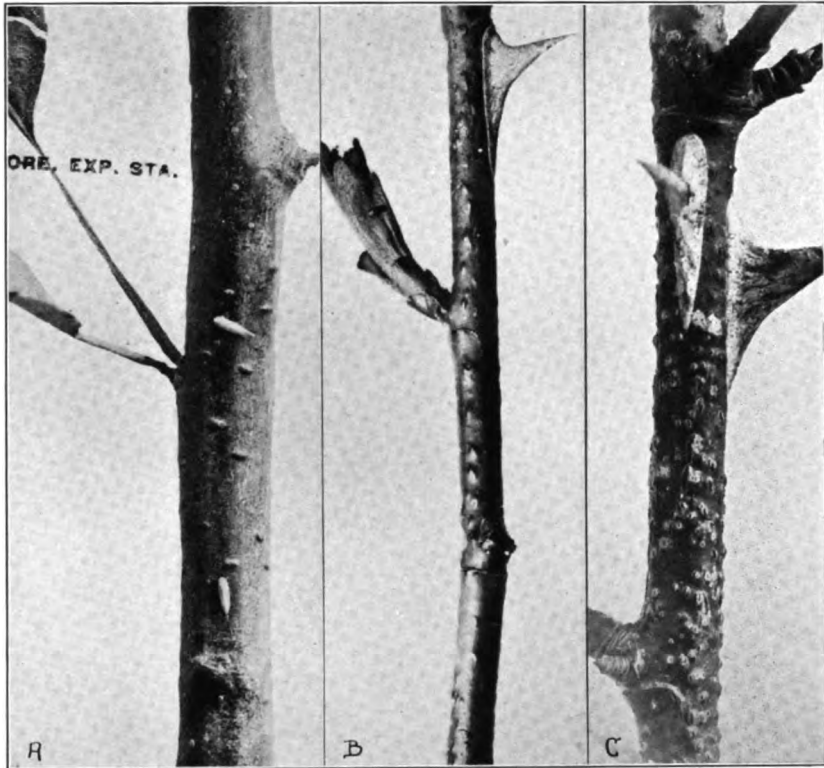


Figure 10. Rose leaf-hopper and eggs. (a) Twig of apple showing leaf-hoppers ovipositing; (b) Pimples on rose twig containing eggs; (c) Appearance of rose twig the year following the deposition of eggs. The twig is badly diseased.

effectively. This point is absolutely essential in order to obtain desired results when putting into practice control measures. This method of spraying from below for the control of scab has been urged by the writer for three or four years in the Hood River section, and has been found to be very effective in destroying the young hoppers.

Though no experiments have been conducted with sulfur dust as a means of controlling this insect, the writer has observed in some of the scab control

experiments under way that the dust material has a decidedly beneficial influence in reducing the numbers of hoppers in the apple orchards. These observations were not checked up closely, but there was a very apparent difference existing between unsprayed check trees and those that had been dusted. From observations that have been made it is believed that the presence of fine particles of dust on the under surfaces of the leaves at the time the eggs hatch is as effective in destroying the insects as dusting them after they have hatched.

Conclusion

There are, in the Pacific Northwest, two generations a year of the rose leaf-hopper, *Empoa rosae*.

During certain years the rose leaf-hoppers occur in sufficient numbers to warrant control measures.

The extent of injury resulting from the myriads of sucking insects usually present on apple, is difficult to estimate. This injury becomes noticeable through the mottling and yellowing of the foliage.

The leaf-hoppers do not, as has been supposed, feed upon the fruit. Feeding habits are confined entirely to the under surfaces of the foliage.

The rose leaf-hopper reaches the adult stage through five successive moults. The nymphal period requires 35.6 days for the first brood, 23.7 days for the early forms of the second generation and 34 days for the later ones. From breeding cage observations, it appears that individuals of the first generation live as long as 116 days; those of the second generation 129 days.

Rosaceous plants are the chief food plants of the rose leaf-hopper. Of these, the rose, though it serves as the host plant of but one generation, is by far the favorite food plant, and suffers the greatest injury due to the presence of this insect. The apple, and to a very limited extent the strawberry, are the only plants upon which both spring and summer generations have been observed to occur.

In locations where leaf-hoppers had an opportunity to choose the most desirable host plants in which to deposit over-wintering eggs, it has been found that 92.7% of the eggs are deposited in the canes of the rose. This pronounced choice for the rose as an egg depository offers a medium by which this insect can be kept well under control. Very few over-wintering eggs are found in apple twigs in the proximity of rose bushes. It is believed that if rose bushes and hedges are properly trimmed and sprayed before the insects become winged, much success in keeping down the numbers of insects in the apple orchards will result.

The use of lime-sulfur in the ten-day and thirty-day scab sprays has been found effective in controlling the first generation in apple orchards. The spray has to be applied while the insects are in the first to third nymphal stages in order to be effective. After this period, Black leaf forty, 1-1200 plus 5 pounds of soap to 100 gallons of water, has been found satisfactory in destroying the hoppers.

On roses, Black leaf forty, 1-2000 plus 5 pounds of soap to 100 gallons of water, is effective when applied to insects in the first to third stages of their growth. For insects in the last two stages of their development in-

crease the Black leaf to 1-1200. All sprays should be directed upward, in order to strike the insects, which are all located on the under surfaces of the leaves.

Parasites and predaceous enemies play little part in the economy of *E. rosae*. The egg parasite *Anagrus armatus*, Ash., is the only insect which has been found materially to reduce the numbers of leaf-hoppers. One-third to one-fifth of the leaf-hopper eggs have been found parasited by this insect at different times.

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